DURABLE FLUORESCENT DIAMOND GRADE SHEETING (DFDG)
FOR CONSTRUCTION & MAINTENANCE PROJECTS.
<table>
<thead>
<tr>
<th>Report No.</th>
<th>Subject Area</th>
<th>Project No.</th>
<th>Report Date</th>
<th>Type of Report</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABTR/MM/RR-98/01</td>
<td>Traffic signs</td>
<td></td>
<td>Jan. 1998</td>
<td>Interim</td>
</tr>
</tbody>
</table>

**Title and Subtitle**

Durable Fluorescent Diamond Grade Sheeting (DFDG) for Construction & Maintenance Projects.

**Author**

Joe Filice, R.E.T., Road/Bridge Materials Technologist

**Performing Organization Name and Address**

Technical Services Branch  
Alberta Transportation and Utilities  
Twin Atria Building  
4999 - 98 Avenue  
Edmonton, Alberta, Canada  
T6B 2X3

**Sponsoring Agency Name and Address**

Alberta Transportation and Utilities  
Twin Atria Building  
4999 - 98 Avenue  
Edmonton, Alberta, Canada  
T6B 2X3

**Supplementary Notes**
The author would like to thank the following regional personnel: Alf Tauscher, Bill Gish and Cindy MacGowan for their assistance in this evaluation. He would also like to thank Sandstar Corporation, Wapiti Sand and Gravel Ltd and Carmacks for cooperating in using the new signs for evaluation purposes.

**Abstract**

Scotchlite Durable Fluorescent Diamond Grade Sheeting (DFDG) is a registered trade name for reflective sign sheeting product developed by 3M Canada Ltd.

In the 1997 construction season, DFDG signs were used in the Peace Region, North Central Region and Southern Region. Day time viewing evaluations were conducted on site to assess the effectiveness of improving work zone safety on Alberta Highways by using the DFDG signs.

During the use of the DFDG signs on several construction projects it became evident that these signs are highly visible, easy to read and help improve work zone safety. DFDG signs should be used on all construction projects to improve work zone safety.

**Key Words**

**Distribution**

Unlimited

**Project Coordinator**

Ted Harrison, P. Eng., Road Materials Engineer
Table of Content

1.0 INTRODUCTION .................................................................1
2.0 OBJECTIVES ........................................................................2
3.0 BACKGROUND .....................................................................2
4.0 DEMONSTRATION PROJECTS ...........................................2,3
5.0 EVALUATION SITE DESCRIPTION .......................................3,4
6.0 RESULTS .............................................................................4,5,6
7.0 SPECIFICATIONS ..................................................................6
8.0 COST ..................................................................................6
9.0 DISCUSSION OF RESULTS ................................................6,7
10.0 CONCLUSIONS AND RECOMMENDATIONS .....................7
11.0 ACKNOWLEDGEMENTS .....................................................7,8

APPENDIX A - Reflective sheeting comparisons of highway 16 paving (regional Safety Officers report & photos)

APPENDIX B - Material Specification

APPENDIX C - Field evaluations of highway 16 paving contract

APPENDIX D - Warranty of reflective sheeting

APPENDIX E - Implementation Plan for Temporary Signs & Barricades
Reflective Sheeting Requirements
NOTICE

This report is published without prejudice as to the application of the findings and is disseminated in the interest of information exchange. Alberta Transportation and Utilities does not endorse products or manufacturers. Trademarks and/or manufacturers appear only where it is considered essential to the object of the report.

Use of Construction and Temporary Signing Shall be Fully Reflectorized using High Brightness Retro reflective Non-Metallized Prismatic Sheeting Material.

1.0 INTRODUCTION

In 1997, the department undertook the task to look at improving work zone safety through the evaluation of a new material from 3M called "Scotchlite Durable Fluorescent Diamond Grade Sheeting" (DFDG). In construction zone situations, there is a critical need for highly-visible, easy to read signs and symbols that help drivers of all ages make safe driving decisions that help reduce work zone hazards. This new product is recommended in construction zones and offers exceptional day time viewing and nighttime Luminance.
2.0 OBJECTIVES

The objective of this project was to evaluate the effectiveness of improving work zone safety on Alberta Highways by using "Durable Fluorescent Diamond Grade Sheeting" for temporary signs and barricades. The primary objective supports the department mandate to provide a substantial improvement to work zone safety for both the contractor and the travelling public.

3.0 BACKGROUND

Senior department officials attended demonstrations on Mar. 10, & Oct. 28, 1997. The demonstrations were set up by a 3M representative and consisted of different sheeting materials (Engineered Grade, High Intensity & Diamond Grade). The signs were placed side by side at several different locations at the Department's 50 St. yards and were viewed at dusk and then again at night. It was evident that the DFDG product stood out over all the other signs. A.T. & U. staff were impressed with the DFDG product and agreed that it would provide substantial improvement to work zone safety due to higher visibility for both day and night time driving.

4.0 DEMONSTRATION PROJECTS

In May, 1997, "Durable Fluorescent Diamond Grade sheeting" (DFDG) was used on several construction projects and maintenance work for evaluation purposes. The DFDG signs were used at the following locations:

North Central Region


Peace Region

- Paving contract, highway 2:60, east Peace River hill (Contractor: Wapiti Sand & Gravel Ltd.).
Southern Region

Maintenance contractor used on various maintenance work (Contractor: Carmacks).

The following DFDG signs were supplied to the contractors by 3M Canada for evaluation:

- 2 RB-1 - Maximum 50km/hr
- 2 WD-101 - Construction Ahead
- 2 WD-170 - Construction Ahead 2 Km
- 2 WD-A-41 - Men Working Symbol

Durable Fluorescent Diamond Grade Sheeting is a registered trade name (3M) for a high brightness Retro reflective prismatic sheeting used for construction work zone signs. The material is non-metallized, hence providing excellent colour both day and night. Material exhibits exceptional performance at high incidence (entrance) angles.

These DFDG signs have been identified with a date (May 97) stamped on the back of each sign. There are two sets of these signs that have been provided by 3M to be used throughout the province. These DFDG signs are being considered for use on a bridge contract for which construction will begin 1998.

5.0 EVALUATION SITE DESCRIPTION

North Central Region

Highway 16X:40 & 42 evaluation site is located W. of Jct. S.H.779 Edmonton City Limits.

Both test sites are located on a four lane divided highway in close proximity to Edmonton with very high traffic volumes. Safety is a major concern on this highway due to its high traffic volume.
Southern Region

Signs were used during maintenance operations, where safety is a major concern due to the urgency in completing the repair.

Peace Region

Highway 2:60 evaluation site is located on the East Peace River Hill.
Safety was a prime concern on this paving contract due to the steepness of the Peace River hill and the high traffic volumes.

6.0 RESULTS

North Central Region

Highway 16:14 Evaluation Site
This site was first evaluated on May 15, 1997, at approximately 2:30 P.M. The weather was 20°C with sunny skies. Traffic was extremely heavy which is normal for this highway at that time of day. The evaluation from this visit is as follows:

- There appears to be a greater public awareness of the construction zone with the use of the diamond grade fluorescent orange signs.
- The diamond grade orange signs are clearly more visible from further away by approaching traffic.
- When comparing the effectiveness of the Engineer grade orange signs to that of the diamond grade orange signs, it was evident that the diamond grade is a dramatic improvement in day time viewing and that it therefore improves work zone safety.

A second evaluation was conducted on June 2, 1997, at approximately 10:30 A.M., the weather was 20°C with partly cloudy skies. Traffic conditions were heavy with large amounts of truck traffic. The evaluation from this visit is as follows:
It was evident that the diamond grade fluorescent orange signs are clearly more visible to the travelling public. The diamond grade fluorescent signs definitely stand out over all other existing signs in the area.

It is clear that there is a greater public awareness of the construction zone due to the presence of these highly visible diamond grade fluorescent orange signs.

The diamond grade fluorescent orange signs are visibly superior to the engineered grade signs that were present at the construction site.

The contractor (Sandstar Corporation) had several of their own 2-year old diamond grade fluorescent orange signs on site and they were still performing very well. From a durability standpoint these older signs are holding up very well.

**Highway 16X: 40 & 42 Evaluation Site**

This site was also evaluated on May 15, 1997 at approximately 3:30 P.M. There was no construction activity going on at this time. However several diamond grade signs were up and they were clearly more visible than any other signs present.

**Southern Region**

**Maintenance Contractor (Carmacks)**

The regional staff assessed the DFDG signs at various maintenance work sites. The reflectivity of the signs is very good, however only for a short time. These signs are damaged quickly as they are put up and taken down often. Once they are chipped, they are no longer any more visible than high intensity signs. The Calgary regional staff's recommendations are as per the following:

- For maintenance purposes, unless the DFDG signs have a
protective coating, they aren't worth having due to the higher cost as they only perform for a short period of time.

**Peace Region**

Highway 2:60 East Peace River Hill evaluation Site
- The contractor and department personnel were very pleased with the DFDG signs on this project as they are clearly more visible to the travelling public than any other signs present. These signs definitely create a greater public awareness of the construction zone and greatly improve workzone safety.

**7.0 SPECIFICATIONS**

Specification of this new product is included in Appendix B.

**8.0 COST**

The following is the list price for Engineered grade sheeting and % increase for High Intensity and Diamond grade:
- Engineered grade - $14.00/sq.ft.
- High Intensity - 30% increase
- Diamond Grade - 60% increase

**9.0 DISCUSSION OF RESULTS**

The DFDG orange sheeting has been used for several years on signs in Alberta by construction contractors. From a durability standpoint the signs that have been assessed are standing up very well. The diamond grade orange sheeting has a 3 year manufacturers warranty, the manufacturer will replace or repair the entire sign if failure occurs during this period due to debonding from substrate.
The Alberta Roadbuilders and Heavy Construction Association (ARA) was asked to provide comments/feedback on the use of the DFDG signs. The ARA had the following comments:

- No concern or negative feedback from contractors on the use of DFDG signs.
- The major concern expressed by the contractors was the cost difference between diamond grade and engineered grade signs.
- Damage to these signs has been minimized as a result of improved handling resulting from the awareness of the higher cost passed down to the workers.

10.0 CONCLUSIONS AND RECOMMENDATIONS

This demonstration project was not expected to provide hard data on improved work zone safety but was to provide contractors with working samples for field evaluation. The awareness of the higher cost may have impacted the general handling of these signs. The implementation plan listed below for Temporary Signs and Barricades Reflective Sheeting Requirements has been jointly agreed to by A.T.&U. and ARHCA, and specifications will be amended to reflect these changes:

- No temporary signs or barricades with Level 1 (High Intensity) sheeting material manufactured after December 31, 1997 will be allowed on AT&U Construction or Maintenance Projects.
- Signs manufactured prior to December 31, 1997 will be accepted until January 1, 2000 or when the Highway Maintenance Contracts are renewed or extended.

11.0 ACKNOWLEDGEMENTS

The author would like to thank the following for their assistance:
Frank Shackleton, 3M Canada Company
Allan Russell, Alberta Traffic Supply Ltd.
Gene Connorn, Sandstar Corporation
Bill Gish, Alberta Transportation and Utilities
Cindy MacGowan, Alberta Transportation and Utilities
Alf Tauscher, Alberta Transportation and Utilities
Appendix A

Reflective Sheeting Comparisons Highway 16 Paving

Regional Safety Officers Report and Photos
Flourescent Orange Diamond Grade signs. (Sandstar July 1995) This sign has been in use for over 1 1/2 years and still is in very good condition.

Note the wear on the black lettering. The letters are slowly being worn off but the sign sheeting is not yet damaged, therefore the sign reflectivity has not yet been damaged.
"Construction Ahead" WD-101 sign. Even though it has been in use for a number of years it is still very visible.

Close up view of the above sign shows the letters being worn off. Also there are a few surface scratches but they have not penetrated the sheeting, thus is still reflective at night. Note that this sign is quite dusty with some foot prints on it.
"Left Lane Ends" WD-A-33L sign. This sign is new (May 1997). No wear or scratches.

Close up view showing no damage to sign.
"Flagperson Ahead" WD-A-45 sign. Left side is the Fluorescent Orange Diamond Grade sign and the right is the Engineer Grade sign.

Closer view of the above. It should be noted the left sign is dirty from dust and moisture, however it still is more visible than the right sign.
"Flaggerperson Ahead" WD-A-45 sign Flourescent Orange Diamond Grade sign. Upon a closer look from previous page it is evident that the sign is dirty, however it did not show up from further back.

Engineer Grade sign, one year old. It is still in very good condition, however it is not as visible as the one noted above, even though it was dirty.
Appendix B

Material Specification
1 MODIFICATION TO SPECIFICATION 7.1, CONSTRUCTION AND TEMPORARY SIGNING REGARDING THE TYPE OF REFLECTIVE MATERIAL

Revise Section 7.1.2 first paragraph last sentence to read, All construction signs and barricades shall be fully reflectorized using High Brightness, Retroreflective, Non-Metallized, Prismatic Sheeting Material. This material incorporates a highly conspicuous and durable transparent fluorescent pigment.

Material Specification:

General Description:
A high brightness retroreflective material of non-metallized prismatic construction. This material incorporates a highly conspicuous and durable transparent fluorescent pigment. Typical applications for this material are traffic signing in highway workzones, or any area which requires materials offering exceptional daytime conspicuity and nighttime luminance.

**Brightness Requirements:**

<table>
<thead>
<tr>
<th>Observation Angle</th>
<th>Entrance Angle</th>
<th>Orange</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>-4</td>
<td>200</td>
</tr>
<tr>
<td>0.2</td>
<td>+30</td>
<td>120</td>
</tr>
<tr>
<td>0.2</td>
<td>+50</td>
<td>50</td>
</tr>
<tr>
<td>0.5</td>
<td>-4</td>
<td>80</td>
</tr>
<tr>
<td>0.5</td>
<td>+30</td>
<td>50</td>
</tr>
<tr>
<td>0.5</td>
<td>+50</td>
<td>20</td>
</tr>
</tbody>
</table>

*Minimum Coefficient of Retroreflection (Rv) cd/lx ft² (cd·lx⁻¹·m⁻²).

**Colour Requirements:**

<table>
<thead>
<tr>
<th>Colour</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Reflectance Limit (Y) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orange (new)</td>
<td>.583</td>
<td>.416</td>
<td>.523</td>
<td>.397</td>
<td>.560 .360 .631 .369</td>
</tr>
<tr>
<td>Orange (weathered)</td>
<td>.583</td>
<td>.416</td>
<td>.523</td>
<td>.397</td>
<td>.560 .360 .631 .369</td>
</tr>
</tbody>
</table>

Maximum special radiance factor: new 110% minimum, weathered: 60% minimum

The four pairs of chromaticity coordinates determine the acceptable colour in Terms of the CIE 1931 Standard Colorimetric system measured with Standard Luminant C.

Durability: 50% retention of the values in the above brightness table after 1500 hours of artificial weathering in accordance with ASTM G 26, Type B, Method A. In addition, the colour values after weathering shall conform to the requirements set out in the colour chart (above).
Appendix C

Field Evaluations of Highway 16 Paving Contract
FROM Alf Tauscher  
Regional Safety Officer  
North Central Region

TO Robert D. Huddleston  
Manager  
Safety and Organization Development

OUR FILE REFERENCE 1285-1

SUBJECT Construction Zone Signs - Reflective Sheeting

As you are aware we did a test on the reflective sheeting of construction signs on one of our paving projects. It should be noted that Sandstar Corporation has been using the flourescent orange diamond grade signs for the past two years. Some of their used signs were also observed and the pictures that follow are of these signs.

The general observation from talking to numerous people who were unaware of the type of sheeting material being used was they were very noticeable. new, easily seen, stood out from all the rest etc.

My observation was that they did stand out extremely well from any other sign that was used on this project. On many other projects we installed flourescent flags onto construction signs to make them more visible and noticeable, which the flags did.

Flags were also installed by the contractor and when driving through the work zone you hardly noticed the flags as the sign was the one item that was most noticeable. The photos that I took don’t do justice to the colour of the flourescent sheeting, whereas on site they were very bright.

After the observations and comments received, I would suggest that if we decide to make a change in types of reflective sheeting we should definitely go to the Flourescent Orange Diamond Grade material for signs on construction projects.

Alf Tauscher

Attachment

cc: Joe Filice
NOTE TO FILE

File: 1522-4
Date: June 4, 1997

RE: Site Visit of “Durable Fluorescent Diamond Grade Sheeting” Signs on Hwy. 16:14(E. of Jct. Hwy. 43 to E. of R.R. 22

On June 2, 1997, Ted Harrison and Joe Filice conducted a second evaluation on the Durable Fluorescent Diamond Grade construction signs that Sandstar Corporation is using on this project. The weather was warm 20°C with partly cloudy skies and traffic was heavy with large amounts of truck traffic. The following are comments from our site visit:

- It was quite evident that the diamond grade orange signs are clearly more visible to the traveling public. These signs stand out over all existing signs in the area.

- When approaching the diamond grade orange signs it is clear that there is a greater public awareness of the construction zone due to the presence of these highly visible signs.

- The diamond orange grade signs are visibly superior to that of the engineered grade signs that were present at the construction site.

- The contractor (Sandstar Corporation) had several of his own diamond grade (orange) signs on site that are 2 years old and performing very well. From a durability standpoint these older signs are holding up very well.

- Photographs were taken of the diamond grade signs.

Joe Filice

cc: Ted Harrison
NOTE TO FILE

Date: May 16, 1997

File: 1522-4

RE: Site Visit of "Durable Fluorescent Diamond Grade Sheeting" Signs on Hwy. 16:14 and 16X:40

On May 15, 1997, Joe Filice and Ron Stoski visited the above noted sites to evaluate the Durable Fluorescent Diamond Grade construction signs that Sandstar Corporation is using on their paving project. The following are comments from our site visit:

- There is greater public awareness of the construction work zone.
- When comparing the Engineer Grade orange signs to that of the fluorescent orange sign it is evident that the fluorescent orange sign is a dramatic improvement in day time viewing.
- The fluorescent orange signs are clearly visible from further away by approaching traffic.
- Photographs were taken of the signs.

NOTE: 14 Durable Fluorescent Diamond Grade Signs were supplied by 3M for evaluation purposes.

Joe Filice

cc Ted Harrison
Ron Stoski

JF/nv
Appendix D

Warranty of Reflective Sheeting
NOTE TO FILE

File: 1522-4
Date: October 31, 1997

RE: Warranty of Reflective Sheeting Signs

The department is looking at setting up a sign replacement program for the Regional Services Division.

For your information the warranty periods for the various types of reflective sheeting are as follows:

**Engineer Grade**
There is no written warranty on this grade; if there is a problem, it will be looked at on an individual basis by the manufacturer.

**High Intensity Grade**
This grade of sheeting has a 10 year warranty with 80% retention of the initial retro-reflectance as stated in product bulletin tables.

If this type of sheeting fails in the first 7 years, the 3M manufacturer will replace or repair the entire sign (including labour). If failure occurs in the last 3 years, the manufacturer will replace the sheeting only.

**Diamond Grade**
This grade of sheeting has a 7 year warranty with 50% retention of the initial retro-reflectance as stated in product bulletin tables.

If this type of sheeting fails in the first 5 years, the 3M manufacturer will replace or repair the entire sign (including labour). If failure occurs in the last 2 years, the manufacturer will replace the sheeting only.

**Diamond Grade “DFDG Orange”**
The diamond grade orange sheeting has a 3 year manufacturer's warranty on a prorata basis against defects due to manufacturing/quality problems. Warranty does not extend to materials which have been mis-handled or physically damaged.

It was pointed out to me, by the 3M representative, that in most cases the reflective sheetings retain very good reflectance well past the warranty period.

Joe Filice

cc  Ted Harrison
    Steve Otto
    Ron Stoski
Appendix E

Implementation Plan for Temporary Signs & Barricades Reflective Sheeting Requirements
FROM: Allan Kwan  
Executive Director  
Technical Standards Branch  

TO: Regional Directors  

DATE: November 10, 1997  
PHONE: 427-8990  

SUBJECT: Implementation Plan for  
Temporary Signs and Barricades  
Reflective Sheeting Requirements  

The field evaluations of the new reflection sheeting material known as Durable Fluorescent Diamond Grade (DFDG) has been completed.  

The results from regional staff and contractors have been positive and this product will be accepted as the new standard for temporary signs and barricades.  

The implementation plan for introducing this material will follow that which was proposed to the ARHCA in my letter of June 5, 1997 and reads as follows:  

No temporary signs or barricades with Level 1 (High Intensity) sheeting material manufactured after December 31, 1997 will be allowed on Alberta Transportation and Utilities Construction or Maintenance Projects. Signs manufactured prior to December 31, 1997 will be accepted until January 1, 2000 or when the Highway Maintenance Contracts are renewed or extended.  

This implementation plan is in addition to the previous plan which allows signs using Level 2 (Engineer Grade) sheeting material manufactured prior to June 30, 1997 to be accepted until January 1, 1999.  

If you have any questions contact Ted Harrison, Road Materials Engineer at (403)415-1023. Please circulate this notice to the appropriate staff in your region.  

Allan Kwan  

cc  Barrie McPhalen (ARHCA)  
G. Zack (Chair, MPMG)  
M. Znak (Chair, CPMG)  
T. Hawnt  
I. Baird  
B. Huddleston  
S. Hasham/B. Kenny  

TH/nv
June 5, 1997

Barrie McPhalen  
President  
The Alberta Roadbuilders and Heavy Construction Association  
#201, 9333 - 45 Avenue  
Edmonton, Alberta  
T6E 5Z7

Dear Mr. McPhalen:

RE: Implementation Plan For Temporary Signs And Barricades Reflective Sheeting Requirements

Further to our discussion, attached is AT&U’s final implementation plan for temporary signs and barricades reflective sheeting requirements. Would you please advise your members accordingly.

We feel this plan will allow industry a sufficient amount of time to deplete their existing supply of in stock material and will discourage stockpiling of signs which would not meet the revised specification requirements.

Yours truly,

Allan Kwan, P. Eng.  
Executive Director  
Technical Standards Branch

AK/im  
cc  G. Zack (Chair of MPMG)  
M. Znak (Chair of CPMG)  
T. Hawnt

bcc  A. Waters, R. Penny, J. Schroder, B. Zaututas  
C. MacGowan, K. LaPierre, A. Griffith, T. Mammen, Kp Smith  
T. Carter, A. Brown  
D. Camplin, B. Gish  
B. Huddleston, I. Baird, T. Harrison, S. Hasham, B. Kenny  
J. Sawchuk, L. O’Neill
Implementation Plan
for Temporary Signs and Barricades Reflective Sheeting Requirements

The following implementation plan is being recommended to facilitate the enforcement of the specification requirements for reflective sheeting material used on Temporary Signs and Barricades.

Highway Construction Contracts

• Effective immediately no temporary signs or barricades with Level 2 (Engineer Grade) sheeting material manufactured after June 30, 1997 will be allowed on AT&U Construction Projects.
• Temporary signs and barricades manufactured prior to June 30, 1997 will be accepted until January 1, 1999.
• Effective January 1, 1998 flags will be required on all portable signs.

Highway Maintenance Contracts

• Temporary signs and barricades must be Level 1 (High Intensity) sheeting material as specified in Specification 55.1 “Traffic Accommodation and Temporary Signing”.
• Any sign not meeting this requirement must be replaced by January 1, 1998.

The Department will deal with each Area Maintenance Contractor on an as required basis if the enforcement of the specification impacts the delivery or over cost of services.

The Department is currently evaluating a new reflective sheeting material known as Durable Fluorescent Diamond Grade (DFDG). Should it be agreed to change the specifications requirements to DFDG sheeting material for temporary signs and barricades we would adopt a similar implementation plan for the existing Level 1 (High Intensity) signs. That is:

• No temporary signs or barricades with Level 1 (High Intensity) sheeting material manufactured after December 31, 1997 will be allowed on AT&U Construction or Maintenance Projects. Signs manufactured prior to December 31, 1997 will be accepted until January 1, 2000 or when the Highway Maintenance Contracts are renewed or extended.